

TOSS-UP

1) Chemistry – *Short Answer* The energy of a given level for a one-dimensional particle-in-a-box is proportional to the length of the box raised to what power?

ANSWER: NEGATIVE TWO

BONUS

1) Chemistry – *Multiple Choice* The entropy of a system is directly proportional to which of the following quantities?

W) The number of microstates

X) The square of the number of microstates

Y) The square root of the number of microstates

Z) The log of the number of microstates

ANSWER: Z) THE LOG OF THE NUMBER OF MICROSTATES

TOSS-UP

2) Earth and Space – *Multiple Choice* Which of the following best describes the shape of the geoid?

- W) Smooth and oblate
- X) Uneven and oblate
- Y) Smooth and prolate
- Z) Uneven and prolate

ANSWER: X) UNEVEN AND OBLATE

BONUS

2) Earth and Space – *Short Answer* Identify all of the following three statements that are true of volcanoes: 1) Parasitic cones are typically associated with newly-formed volcanos; 2) Basaltic volcanoes tend to have shallower slopes than felsic volcanoes; 3) Lava domes are primarily rhyolitic in composition.

ANSWER: 2

TOSS-UP

3) Energy – *Short Answer* Scientists supported by the Department of Energy are studying organisms that produce mRNA molecules with several genes on them. What is the adjective for this type of mRNA?

ANSWER: POLYCISTRONIC

BONUS

3) Energy – *Short Answer* Scientists at Argonne National Lab are studying a collective excitation of electron spin in a crystal lattice. Identify all of the following three values of spin that these excitations can have: 1) 1; 2) $\frac{1}{2}$; 3) $\frac{3}{2}$.

ANSWER: 1

TOSS-UP

4) Math – *Multiple Choice* In data that are normally distributed, an observation that is one standard deviation above the mean is closest to which of the following percentiles?

W) 34

X) 68

Y) 84

Z) 95

ANSWER: Y) 84

BONUS

4) Math – *Short Answer* Identify all of the following three points that lie on the line with parametric equations $x = 3t - 1$, $y = -2t + 5$, and $z = 4t + 3$: 1) $(11, -3, 19)$; 2) $(5, 1, 8)$; 3) $(-10, 11, -9)$.

ANSWER: 1, 3

TOSS-UP

5) Physics – *Multiple Choice* A spring consists of a coil of conducting wire, and is initially at equilibrium. A battery is then connected to the spring so that a constant current runs through its wire. Which of the following best describes the resulting behavior of the spring?

W) It compresses

X) It expands

Y) It remains in equilibrium

Z) It oscillates

ANSWER: W) IT COMPRESSES

BONUS

5) Physics – *Short Answer* In the drag equation, identify all of the following three quantities that determine the drag coefficient of an object: 1) Cross-sectional area; 2) Mass; 3) Shape.

ANSWER: 3

TOSS-UP

6) Biology – *Short Answer* What is the term for RNA that acts as a catalyst?

ANSWER: RIBOZYME

BONUS

6) Biology – *Short Answer* Identify all of the following three proteins that are transmembrane proteins: 1) Aquaporin; 2) Voltage-gated sodium channel; 3) Ras.

ANSWER: 1, 2

TOSS-UP

7) Chemistry – *Multiple Choice* Which of the following ions has the largest polarizability?

- W) Iodide
- X) Chloride
- Y) Bromide
- Z) Fluoride

ANSWER: W) IODIDE

BONUS

7) Chemistry – *Multiple Choice* Which of the following best explains why calcium sulfate becomes less soluble in water as temperature rises?

- W) Its dissolution is exothermic
- X) Combination reactions become faster at higher temperatures than decomposition reactions
- Y) Different hydrates form at higher temperatures, which are less soluble in water
- Z) Calcium sulfate decomposes at high temperatures into an insoluble compound

ANSWER: W) ITS DISSOLUTION IS EXOTHERMIC

TOSS-UP

8) Earth and Space – *Short Answer* What is the term for the phenomenon by which a magnetic field can broaden spectral lines?

ANSWER: ZEEMAN EFFECT

BONUS

8) Earth and Space – *Multiple Choice* Which of the following is primarily responsible for nucleosynthesis of first-row d-block metals?

W) Exploding white dwarfs

X) Merging neutron stars

Y) Dying low mass stars

Z) Cosmic ray fission

ANSWER: W) EXPLODING WHITE DWARFS

TOSS-UP

9) Energy – *Multiple Choice* Scientists at Pacific Northwest National Lab are studying humus. What process produces most humus?

- W) Fermentation
- X) Photo-oxidation
- Y) Respiration
- Z) Mechanical weathering

ANSWER: W) FERMENTATION

BONUS

9) Energy – *Multiple Choice* Scientists at SLAC are studying anti-Stokes Raman scattering. Which of the following best describes this scattering?

- W) Elastic
- X) Inelastic and the photon loses energy
- Y) Inelastic and the matter gains energy
- Z) Inelastic and the matter loses energy

ANSWER: Z) INELASTIC AND THE MATTER LOSES ENERGY

TOSS-UP

10) Math – *Short Answer* What is the coefficient of the x^3 term in the product of the following two quadratic polynomials: $2x^2 - 6x + 7$ and $x^2 + 7x - 2$?

ANSWER: 8

BONUS

10) Math – *Short Answer* What is the cosine of the angle between the vectors $5\mathbf{i} + 4\mathbf{j} + 2\mathbf{k}$ and $4\mathbf{i} - 2\mathbf{j}$?

ANSWER: $2/5$ (ACCEPT: 0.4)

TOSS-UP

11) Physics – *Multiple Choice* What is the term for a process in which heat does not flow in or out of the system?

- W) Isothermal
- X) Quasi-static
- Y) Adiabatic
- Z) Cyclic

ANSWER: Y) ADIABATIC

BONUS

11) Physics – *Short Answer* An RC circuit consisting of a 20-ohm resistor and a 5-microfarad capacitor has 400 microcoulombs of charge initially placed across the capacitor. In amperes, what is the initial current that will flow through the circuit when it is closed?

ANSWER: 4

TOSS-UP

12) Biology – *Multiple Choice* In their famous experiment, Meselson and Stahl used a heavy isotope of nitrogen to prove that DNA replication follows which of the following models?

- W) Conservative
- X) Semiconservative
- Y) Dispersive
- Z) Quasi dispersive

ANSWER: X) SEMICONSERVATIVE

BONUS

12) Biology – *Short Answer* Identify all of the following three statements that are true of mycorrhizae: 1) The hyphae can penetrate the plasma membranes of the host cells; 2) They can improve nutrient uptake for the plant; 3) They are primarily mutualistic.

ANSWER: 2, 3

TOSS-UP

13) Chemistry – *Short Answer* What is the order of the reaction N_2O_4 yields 2NO_2 ?

ANSWER: ONE (ACCEPT: FIRST)

BONUS

13) Chemistry – *Short Answer* Identify all of the following three reactions that have a dimensionless equilibrium constant: 1) $\text{S}_8 + \text{F}_2$ yields SF_6 ; 2) $\text{Zn} + \text{HCl}$ yields $\text{ZnCl}_2 + \text{H}_2$; 3) $\text{P}_4\text{O}_{10} + \text{H}_2\text{O}$ yields H_3PO_4 .

ANSWER: NONE

TOSS-UP

14) Earth and Space – *Short Answer* For what type of water wave is cohesion the restoring force?

ANSWER: CAPILLARY WAVES

BONUS

14) Earth and Space – *Short Answer* Place the following three events in Earth history in chronological order: 1) Core separation; 2) Moon-forming impact; 3) Formation of atmosphere.

ANSWER: 1, 2, 3

TOSS-UP

15) Energy – *Short Answer* Scientists at Brookhaven National Lab are studying the effect that causes the expulsion of magnetic fields from a superconductor. What is the name of this effect?

ANSWER: MEISSNER EFFECT

BONUS

15) Energy – *Multiple Choice* Scientists at Oak Ridge National Lab are studying compounds produced by rhizobial bacteria. These bacteria are typically found associated with the roots of what plants?

- W) Citrus
- X) Ferns
- Y) Liverworts
- Z) Legumes

ANSWER: Z) LEGUMES

TOSS-UP

16) Math – *Short Answer* How many positive integers less than 222 are divisible by 6 and by 8?

ANSWER: 9

BONUS

16) Math – *Short Answer* What is the radius of a circle inscribed in a right triangle with sides of length 12, 35, and 37?

ANSWER: 5

TOSS-UP

- 17) Physics – *Multiple Choice* The motion of an underdamped harmonic oscillator can be written as the real part of an exponential of a product of time with a constant. Which of the following best describes the real and imaginary components of this constant?
- W) Positive real part, non-zero imaginary part
 - X) Positive real part, zero imaginary part
 - Y) Negative real part, non-zero imaginary part
 - Z) Negative real part, zero imaginary part

ANSWER: Y) NEGATIVE REAL PART, NON-ZERO
IMAGINARY PART

BONUS

- 17) Physics – *Short Answer* A block is resting on an inclined plane that is slowly lifted. When the angle with the horizontal reaches 30 degrees, the block begins to slide down the ramp. To two significant figures, what is the coefficient of static friction between the block and the ramp?

ANSWER: 0.58

TOSS-UP

18) Biology – *Multiple Choice* The LH surge just prior to ovulation in mammals is thought to be triggered by a surge in what other hormone?

- W) Estradiol
- X) Progesterone
- Y) FSH
- Z) TSH

ANSWER: W) ESTRADIOL

BONUS

18) Biology – *Multiple Choice* Which of the following properties of double-stranded DNA makes DNA ligase necessary for successful replication?

- W) Only complementary bases bond to each other
- X) A complementary RNA primer can bind to DNA
- Y) It can only be synthesized in the 5-prime-to-3-prime direction
- Z) The double helix must be untwisted for replication

ANSWER: Y) IT CAN ONLY BE SYNTHESIZED IN THE 5-PRIME-TO-3-PRIME DIRECTION